St Mary's University Twickenham London
Institute of Education

GCSE: Physics (Energy)

Name:……………………………………………………….

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Pre-Session Task

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Statement	Comment
Energy can be created but not destroyed.	
Where energy is transferred in a system, there is no net change to the total energy.	
I can use equations to calculate kinetic and gravitational potential energy.	
Gravitational potential energy store of an object increases as it rolls down a hill.	
Heat, electricity and sound are all forms of energy.	
A boiling kettle has more energy than a hot bath.	

…..there is a certain quantity, which we call energy, that does not change in all the manifold changes which nature undergoes….
That is a most abstract idea, because it is a mathematical principle: it says that there is a numerical quantity, which does not change when something happens. It is not a description of a mechanism, or anything concrete: it is just a strange fact that we can calculate some number and when we finish watching nature go through her tricks and calculate that number again it is the same.'

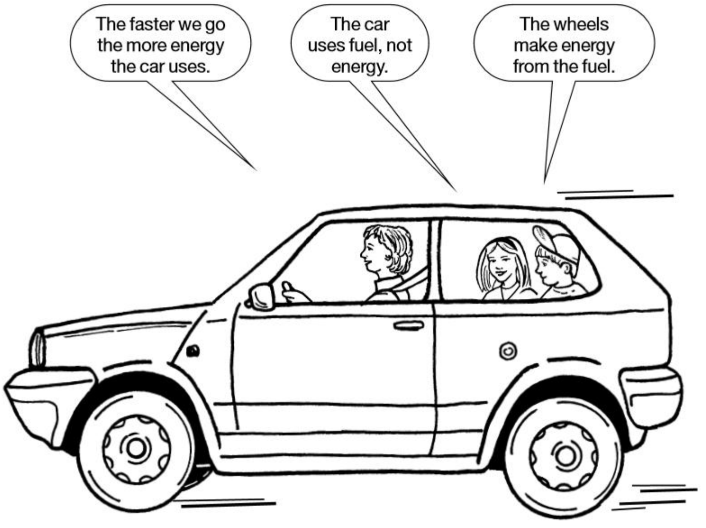
Richard Feynman

Task Check List

Activity	*Page*	*Task details*	*Completed* ✓
1	**4**	Discuss the image below and record your thoughts on each individual's comments within this concept cartoon.	
2	**5**	Indicate your agreement with each of the pupils' comments. Consider how these ideas may have developed. How would you rephrase these statements?	
3	**7**	Calculate the energy for objects A – D	
4	**8**	Calculate energy transferred when using an appliance for one minute.	
5	**9**	Calculate the useful power output	
6	**9**	GCSE Physics required practical activity: Specific heat capacity	
7	**12**	Draw a graph and calculate the gradient.	
8	**12**	Write a method to complete the practical:	
9	**13**	Investigate the effectiveness of different materials as thermal insulators and the factors that may affect the thermal insulation properties of a material.	
10	**14**	Specimen Exam Question	

Pupils' Ideas about Energy

Task 1: Discuss the image below and record your thoughts on each individual's comments within this concept cartoon.



The faster we go the more energy the car uses:

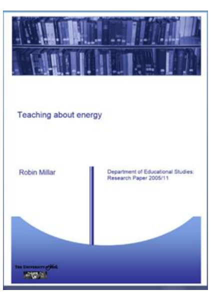
The car uses fuel not energy:

The wheels make energy from the fuel:

Pupils' Ideas about Energy

Task 2: Indicate your agreement with each of the pupils' comments. Consider how these ideas may have developed. How would you rephrase the statements?

Pupils' statements	✓ , X or ?
1 There are many ways of transferring energy, e.g. food, wires, plugs, springs and sunlight.	
2 A car uses petrol energy to make it go.	
3 As the clockwork car moves it uses up the energy in the spring. When all the energy is used it stops going.	
4 Plants make energy from the Sun.	
5 I burnt up the energy from the chocolate when I ran home.	
6 Energy from gravity makes the ball fall down.	
7 Energy makes the rocket go up.	
8 As you get further from the torch the light gets dimmer because the light energy is running out.	
9 The two beakers of water have the same heat.	
10 Joules and calories are sorts of energy.	
Pupil statements found in: Strengthening teaching and learning of energy in Key Stage 3 science Session 1 © Crown copyright 2003	



Two useful texts to read

Millar, R. (2005) Teaching about Energy. Department of Educational Studies: Research Paper 2005/11
https://eprints.whiterose.ac.uk/129328/1/2005_Millar_Teaching_about_energy.pdf

Tracy, C. Energy in the New Curriculum https://spark.iop.org/collections/energy-new-curriculum

What is energy?

Energy is a mathematical concept. It can be used to predict **if** something **could** happen. It isn't a substance that can be handled, and it doesn't explain **why** things happen. To explain why things happen why use physical processes (e.g., forces).

It is useful as energy is a quantity that is conserved. It can be transferred between 'stores'.

Each store has an associated calculation. Energy is measured in Joules (J)

Gravitational potential (associated with work done against a gravitational field (i.e., a change in height))
= mass x gravity x height = mgh

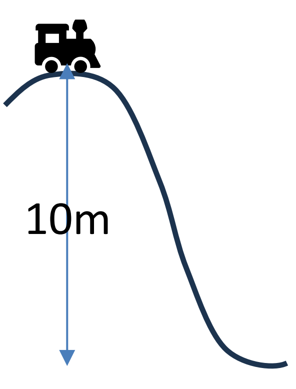
Elastic potential (associated with work done stretching (or squoshing) an object)
= ½ x spring constant x extension x extension = ½ kx2

Kinetic energy (associated with a moving object)
= ½ x mass x velocity x velocity = ½ mv2

Thermal (associated with a change in temperature)
= mass x specific heat capacity x change in temp = mcϴ

Chemical (associated with a chemical reaction. Calculations dealt with in chemistry)

Sometimes it is useful to look at the stores at the start and end of a process or sequence. For example, the gravitational potential energy store of a rollercoaster at the top of the hill can be calculated.
Then by assuming all the gravitational potential energy is transferred to the kinetic store at the base of the hill, the final velocity can be predicted.



Kinetic and Gravitational Potential Energy

Kinetic energy and Gravitational Potential energy
You can calculate the amount of energy associated with a moving object or the amount stored by an object. The energy associated with moving objects is calculated using this simple formula:

Kinetic energy = 0.5 x mass x speed^2 - Immediately you should notice that heavier objects or faster moving objects will have a greater quantity of energy associated with them. Does object A or B 'have' more kinetic energy?

Object A:
Mass = 3500Kg
Speed = 20m/s

Object B:
Mass = 500Kg
Speed = 100m/s

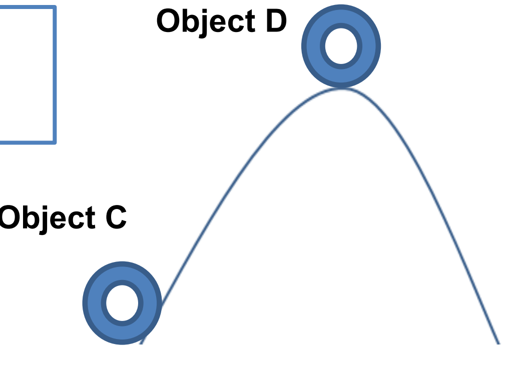
Gravitational Potential energy
The amount of gravitational potential energy gained by an object raised above the ground level can be calculated using the equation:

$$\boxed{Ep = m\,g\,h}$$

Object B is higher off the ground and therefore will have more potential energy associated with it. What affect would a greater mass have on this situation?

Object C: Mass = 5Kg | height = 0m

Object D: Mass = 5Kg | height = 15m



Task 3: Calculate the energy for objects A – C.

Do remember:
Kinetic energy is associated with motion and potential energy is associated with position.

Rate of energy tranfer

Sometimes it's more interesting to think about the rate of energy transfer

The power of an electrical device is defined as the rate at which energy is transferred or the rate at which work is done.

$$Power = \frac{energy\ transferred}{time}$$

Power is measured in joules/second or Watts. An energy transfer of one joule per second is equal to a power of 1 watt.

Energy transfer can happen through a number of different pathways:

Electrical working, mechanical working, radiation or heating by particles.

Task 4: Calculate energy transferred when using an appliance for one minute.

Select 3 items from the table below. Remember to use the appropriate units!

Appliance	Typical
100W light bulb	100W
25" colour TV	150W
60W light bulb	60W
Ceiling Fan	25W
Clock radio	1W
Clothes dryer	1000W
Coffee Maker	800W
Desktop Computer	100W
Dishwasher	1200W
Electric Blanket	200W
Electric Heater Fan	2000W
Electric Kettle	2000W
Fridge / Freezer	150W
Hair Blow dryer	2000W
Home Internet Router	5W
Inkjet Printer	20W
Iron	1000W
Laptop Computer	50W
Microwave	600W
Oven	2150W
Power Shower	7500W
Scanner	10W
Toaster	800W
Vacuum Cleaner	200W
Washing Machine	500W

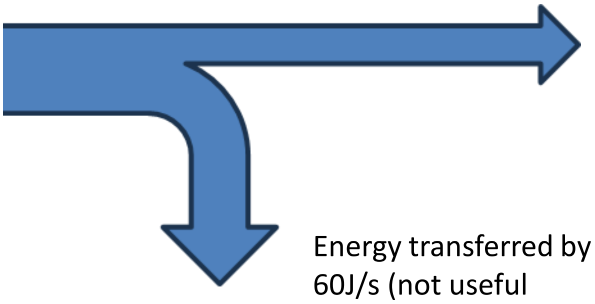
Efficiency

Sometime energy is transferred into less useful stores. Sometimes it's transferred by less useful pathways.

Consider a torch. At the beginning the energy is in the chemical store in the battery. At the end all of the energy is transferred into the thermal store of the room (not so useful).

However, some of it is transferred along the light (radiation) pathway, which is useful. Some of it is transferred along the heating by particles pathway (as the bulb warms) which is less useful.

The efficiency of a process can be shown by a **Sankey** diagram.



A simple calculation can show the efficiency of a machine as either a decimal or a percentage.

$$efficiency = \frac{useful\ output\ energy\ transfer}{total\ input\ energy\ transfer}$$

$$\text{Efficiency} = \frac{40}{100} = 0.4 \text{ or } 40\%$$

Task 5
For the appliances you used in task 4, calculate what their useful power output is, if they are all 85% efficient

GCSE Physics required practical activity: Specific heat capacity not in September completed in isolation in Energy 2

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Task 6: GCSE Physics required practical activity: Specific heat capacity

The **AQA** exam board require that pupils carryout a practical to investigate specific heat capacity. In particular, pupils must **investigate the specific heat capacity of one or more materials.** The investigation will involve linking the decrease of one energy store (or work done) to the increase in temperature and subsequent increase in thermal energy stored.
One method of thinking about the distribution of energy in a system is to calculate storage of energy in terms of temperature change. By heating the metal block using electrical energy we can calculate the energy required to increase the temperature of the block by a set quantity. The electrical energy transferred each second may be calculated by multiplying the voltage and the current. In the diagram you can see a practical setup to collect data that will allow the calculation of the specific heat capacity of the metal block.

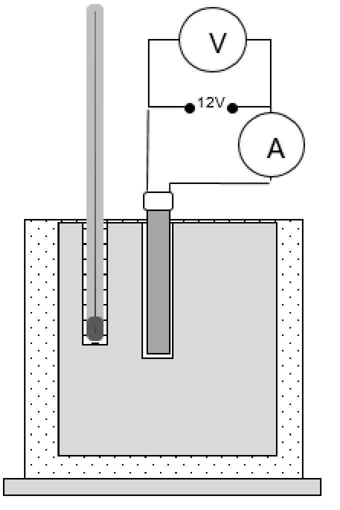


Image used from page 9 of AQA 8463 Practicals Doc

Possible considerations when designing a method:

- Find mass of metal block
- Set up apparatus as seen in diagram.
- Ensure small drop of water is placed in heater hole. (Why?)
- Record ammeter and voltmeter readings for 10 minutes. (Why?)
- Record temperature of block for same 10 minutes. (Why?)
- Should the block be insulated? If so, why?
- What safety considerations should be taken?

Useful formula:

Energy transferred = voltage x current x time

E = V x I x t

$$\Delta E = m \times c \times \Delta\theta$$

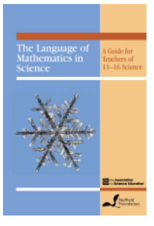
$$SHC = \frac{Energy}{\Delta{}^{\circ}\mathrm{C} \times mass}$$

Concept	Unit
Change in thermal energy ΔE	J
mass	Kg
temperature change Δθ	°C
specific heat capacity, **c**,	J/kg °C

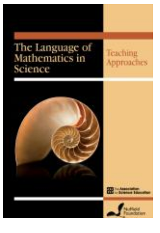
GCSE Physics required practical activity: Specific heat capacity

This practical allows you to focus on the safe use of appropriate apparatus in a context to measure energy changes/transfers and associated values such as work done. It also develops aspects of numeracy and mathematics that have been given far greater emphasis in changes to the GCSE specifications. Our specific heat capacity practical requires several sets of data that may be recorded and manipulated to develop mathematical competence. For example, the table below is suggested by AQA for this practical. Use it to record data for your practical.

The Language of Mathematics in Science: A Guide for Teachers of 11–16 Science



The Language of Mathematics in Science Teaching Approaches



Download from here: http://www.ase.org.uk/resources/maths-in-science/

Time in seconds	Work done in J	Temperature in °C
0		
60		
120		
180		
240		
300		
360		
420		
480		
540		
600		

From your data you may calculate the gradient on a graph. The gradient is a measure of the steepness of a line, and is calculated by dividing the vertical change by the corresponding horizontal change. It represents the rate at which the variable plotted on the vertical axis changes with the variable plotted on the horizontal axis. So, as the energy provided to the system increases the temperature of the block increases.

GCSE Physics required practical activity: Specific heat capacity

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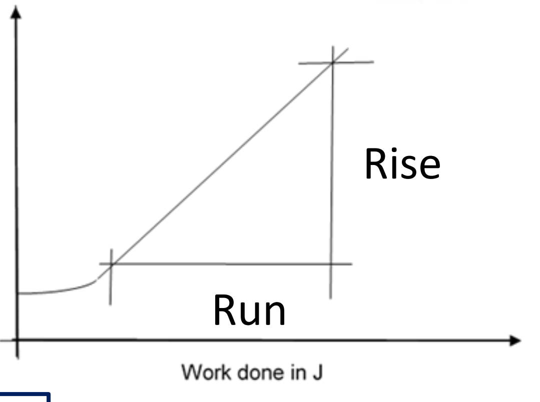
Task 7: ***Draw a graph and calculate the gradient.***

Use the graph paper provided to plot your own graph. From your graph work out the gradient to show the heat capacity of the metal block (Joules per ^{o}C). If you then divide the heat capacity by the mass of the block you will have found the Specific heat capacity (J kg^{-1} C^{-1})

$$\text{Gradient} = \frac{Rise}{Run}$$



Task 8: ***Write a method to complete the practical:***

Why is SHC important? SHC of water is very high, it takes a lot of energy to heat water by one degree –

- this is useful in that it prevents a rapid increase in body temperature.
- Due to the high SHC of water, lakes and the sea heat up slowly and cool down slowly which affects the temperature of the area around the body of water. This is useful for those animals living in the water that need not tolerate large fluctuations in temperature.

GCSE Physics required practical activity: Thermal insulation. Charlie wants to do this on Wed 11th

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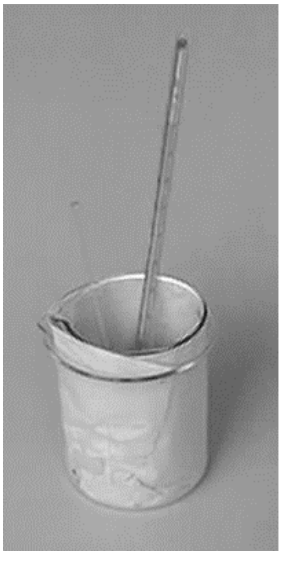
Task 8: Investigate the effectiveness of different materials as thermal insulators and the factors that may affect the thermal insulation properties of a material.

This practical is a little more straight forward and although a required practical for AQA, it is only required for 'physics' candidates.



Use the image on the right to give you a starting point to investigate thermal insulators. You may use different insulators or different quantities of insulator. Again, consider the mathematical skills that may be developed when working on this practical.

It would be good to consider how you might arrange your practical to manage the 'behaviour' of pupils carrying out this task.

- What safety issues must you consider?
- How might you distribute apparatus?
- What size of group would you require?
- How can you distribute tasks to best meet the needs of individuals?
- What alterations may you make to scaffold help for this practical?

Top record results, you could design a simple table that would include the type of material or the thickness of material. The temperature could be recorded at what time intervals and for how long? Do either of these decisions affect how you manage the class?

When drawing a graph for this practical, pupils will place which variable on the x-axis and which variable on the y-axis?

Thoughts?

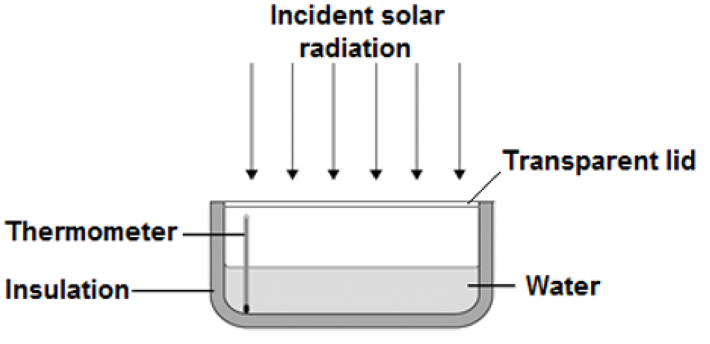
Task 10: Specimen Exam Question

A student investigated how much energy from the Sun was incident on the Earth's surface at her location.

She put an insulated pan of water in direct sunlight and measured the time it took for the temperature of the water to increase by 0.6 °C.

The apparatus she used is shown in **Figure 3**.

Figure 3



0 4 . 1 Choose the most appropriate resolution for the thermometer used by the student.

[1 mark]

Tick **one** box.

0.1 ºC ☐

0.5 ºC ☐

1.0 ºC ☐

The energy transferred to the water was 1050 J.

The time taken for the water temperature to increase by 0.6 °C was 5 minutes.

The specific heat capacity of water is 4200 J/kg °C.

0 4 . 2 Write down the equation which links energy transferred, power and time.

[1 mark]

0 4 . 3 Calculate the mean power supplied by the Sun to the water in the pan.

[2 marks]

Average power = ____________ W

0 4 . 4 Calculate the mass of water the student used in her investigation.

Use the correct equation from the Physics Equation Sheet.

[3 marks]

Mass = ____________ kg

0 4 . 5 The student's results can only be used as an estimate of the mean power at her location.

Give **one** reason why.

[1 mark]

Specimen Exam Question - Answer

Question 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	0.1 (ºC)		1	AO3/3a 4.1.1.3 WS2.3
04.2	power = energy transferred / time	allow P = E / t	1	AO1/1 4.1.1.4
04.3	correct substitution ie 1050 / 300 3.5 (W)	accept 3.5 (W) with no working shown for **2** marks	1 1	AO2/1 AO2/1 4.1.1.4
04.4	1050 = m x 4200 x 0.6 m = 1050 / (4200 x 0.6) m = 0.417 (kg)	(substitution) (rearrangement) (answer) accept 0.417 (kg) with no working shown for 3 marks	1 1 1	AO2/2 4.1.1.3
04.5	any **one** from: • energy used to heat metal pan (as well as the water) • energy transfer to the surroundings (through the insulation) • angle of solar radiation will have changed during investigation • intensity of solar radiation may have varied during investigation		1	AO3/3a 4.1.1.3 WS3
Total			**8**	

Post Session Task

<table>
<tr><th>Statement</th><th>Comment</th></tr>
<tr><td>Energy can be created but not destroyed.</td><td></td></tr>
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Richard Feynman</td></tr>
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